Satellite Radio Frequency Diversity

The second CD Radio innovation is to use satellite transmission radio frequency diversity in combination with satellite spatial diversity to reduce further the required transmission link margin for multipath fading. Essentially one satellite transmits the DARS at a certain frequency in the 2310-2360 MHz band and the second satellite transmits the same DARS at another frequency in the 2310-2360 MHz band separated by approximately 20 MHz as shown in Figure 1. A typical user vehicle receiver is shown in Figure 3. It is estimated that such transmission radio frequency diversity would reduce the additional link budget margin needed for frequency selective fading by at least a factor of two (3 dB) as well as further ensuring statistical independence of the two satellite spatial diversity paths. Radio frequency diversity would not be effective from a single satellite DARS system since the 3 dB saving is counterbalanced by the 3 dB expenditure in satellite transmitter power needed to generate the second radio frequency carrier transmission.

Satellite System Technology

CD Radio has innovated several technological advances into its satellite DARS system by active engineering, sponsorship of directed equipment development and cooperative efforts with other organizations. Among these are the incorporation in the satellite system of leading-edge music compression operating at 128 kb/s, of an advanced automobile antenna with dimensions approximately equal to a silver dollar and of advanced designs of automobile radios providing both integration and user interface. These innovations have enabled the DARS satellite system technology for practical implementation, and CD Radio was first to demonstrate assurance of feasibility.

1. Music Compression. CD Radio has studied music compression for several years and has surveyed the industry. CD Radio demonstrated in November 1991 the use of 256 kb/s music compression in a satellite transmission system. The compression equipment was designed by Dolby and Musicam and the results were submitted to the FCC in its January 1992 Demonstrational Report. Further work in this area convinced CD Radio in early 1992 that stereo CD music could be compressed so that a 128 kb/s transmission rate would be possible by using joint stereo channel encoding. CD Radio's investigation led it to AT&T Bell Laboratories which was developing such a compression system using algorithms based on Perceptual Audio Coding (PAC). Collaboration with AT&T has led to the recent use of 128 kb/s transmission of compressed stereo CD music in a mobile demonstration of CD Radio's satellite system. The performance data, as well as detailed information on the compression system, are contained in the Demonstration Report being submitted concurrently. This is the first ever demonstration of 128 kb/s CD music compression technology in a practical transmission system using geosynchronous satellites. This halving of transmission rate essentially reduces the required satellite EIRP by a factor of two (3 dB).

2. Small Antennas. It is necessary that the user vehicle receiving antennas be small. CD Radio has actively pursued this technology for the past few years and has sponsored several cooperative and funded development efforts to achieve small planar array antennas. In the November 1991 demonstration previously mentioned, satellite transmissions were received with notebook size antennas developed and designed by CD Radio, and manufactured under contract by Ball Aerospace and Seavey Engineering. It was the smallest antenna ever used in the United States to receive CD music from a

satellite and represented an important step in technology development. CD Radio's efforts since then have focused on the development of a smaller antenna suitable for automobile mounting. The result of this CD Radio development effort is a planar array disk antenna approximately the size of a silver dollar for satellite DARS vehicular reception in the 2310-2360 MHz band. The antenna data and a picture of the antenna are presented in the concurrently submitted Demonstration Report where it was successfully operated in a mobile environment emulating the CD Radio DARS system. Again, this is the first ever use of an antenna so small for satellite DARS and represents another significant advance in technology development. It is noted that the antenna has been designed to achieve unit pricing below $10.00 in quantity production.

3. Automobile Radio Design Considerable engineering, design and physical development effort has been accomplished by CD Radio to implement a practical and economical automobile radio including the radio's interface with the automobile's operator. An overall engineering design was finalized in 1991. A top level block diagram is shown in Figure 4. The design was completed in 1992 and the radio is capable of receiving at operator's selection a local AM, FM or DAB terrestrial broadcast signal or the CD Radio DAR signal. The public presentation of the design by CD Radio (Electronic Industries Association; Fall Conference; San Diego, CA; October 20, 1992) was the first known accomplishment of this nature. A prototype radio was completed early in 1993. The concurrently submitted Demonstration Report provides engineering data and pictures of the operational radio* which was extensively used in the demonstration. The interface with the operator is carefully engineered to present

* The radio did not include terrestrial DAB broadcast reception capability since the U.S. standard has not yet been adopted.

on an easily visible display the information of the music available, the music being played and its acquisition.

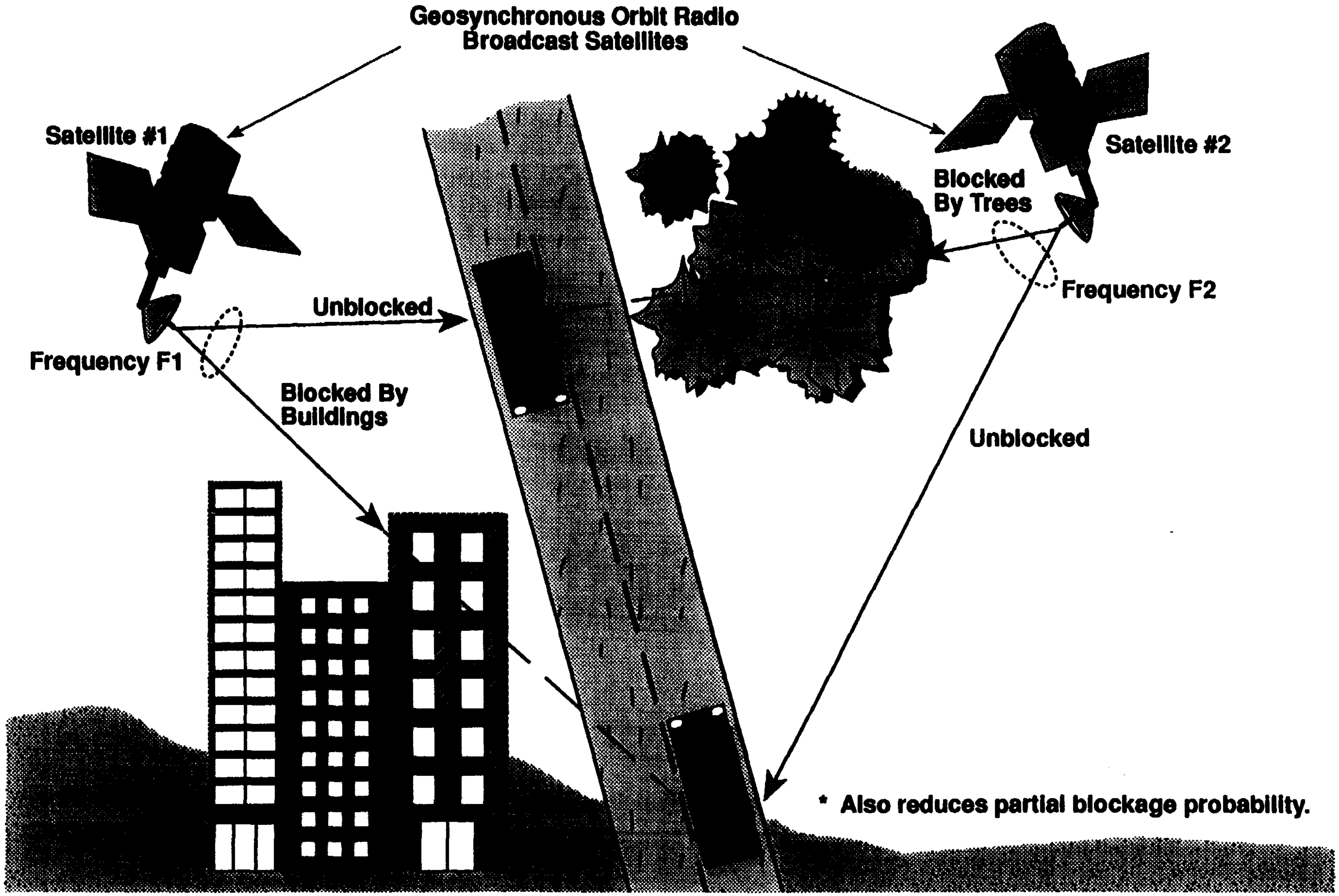
REFERENCES

1. Satellite Sound Broadcasting To Vehicular, Portable And Fixed Receivers In The Range 500-3000 MHz; CCIR Report 955-2, 14 November 1991

2. Direct Broadcast Satellite-Radio Systems Tradeoff Study, Final Report; Nasser Golshan; Jet Propulsion Laboratory (JPL D-9550); Pasadena, CA; March 1992

3. The Characterization Of Propagation Effects For Land Mobile Satellite Services; J. Butterworth & E. Matt; IEE Conference Publication No. 222; 1983

Figure 1 — Reduction of Blockage Outages* By Use Of Two Radio Broadcast Satellites

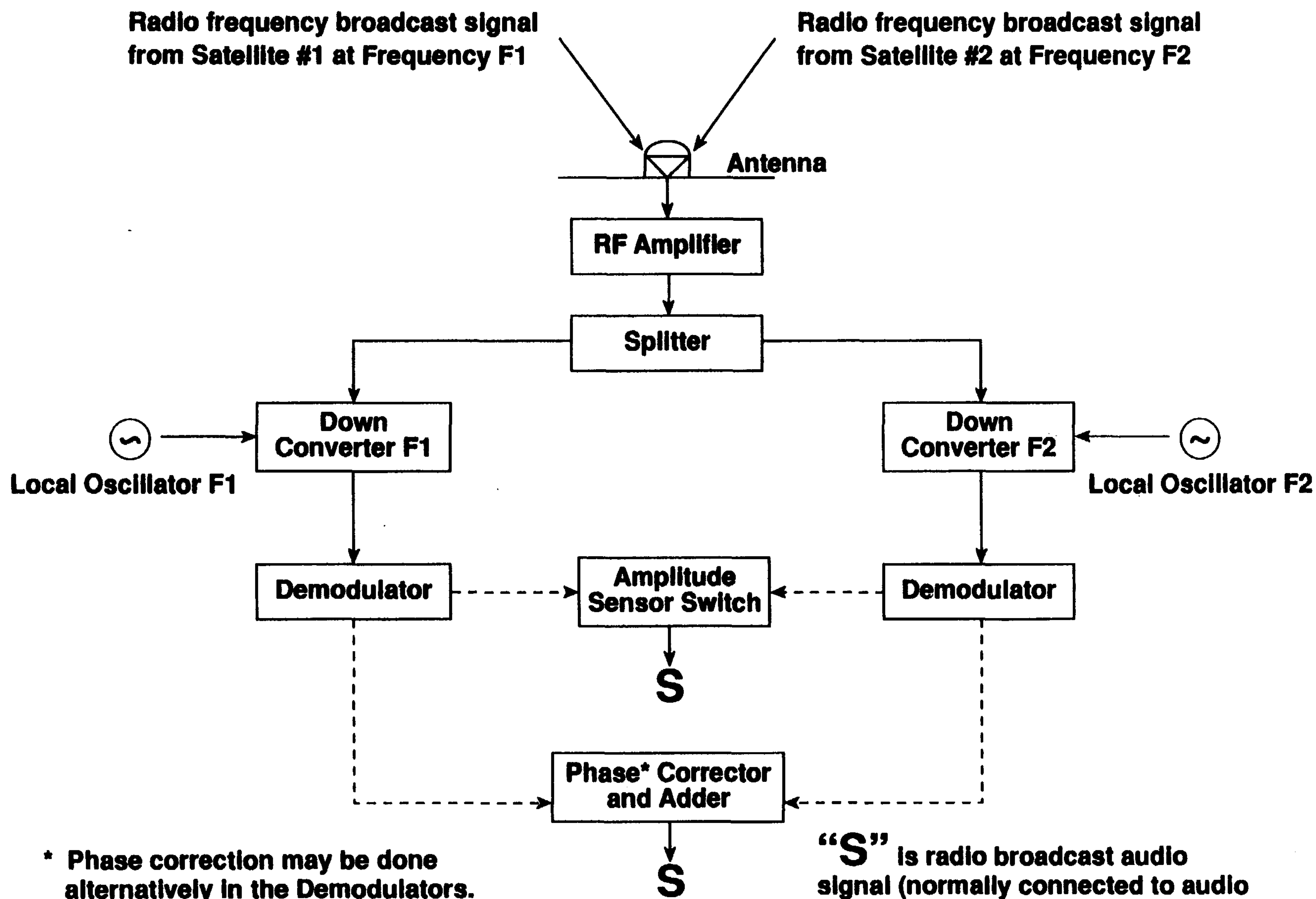


* Also reduces partial blockage probability.

Figure 2 - Satellite Visibility

USER LOCATION			80° W. SATELLITE	110° W. SATELLITE
GEOGRAPHIC	LONG.°	LAT.°	ELEVATION ANGLE°	ELEVATION ANGLE°
CENTER CONUS NORTON, KANSAS	100	40	39.5	42.6
CENTER-EAST CONUS TRENTON, NEW JERSEY	75	40	43.5	31.5
CENTER-WEST CONUS EUREKA, CALIFORNIA	123	40	26.4	41.9
SOUTH-CENTER CONUS SAN ANTONIO, TEXAS	100	30	42.4	53.4
SOUTH-EAST CONUS JACKSONVILLE, FLORIDA	82	30	55.0	43.7
SOUTH-WEST CONUS SAN DIEGO/L.A., CALIFORNIA	117	33	35.1	50.7
NORTH-CENTER CONUS PIERRE, SOUTH DAKOTA	100	45	34.5	37.2
NORTH-EAST OTTOWA, ONTARIO	75	45	38.0	27.7
NORTH-WEST CONUS PORTLAND, OREGON	123	45	23.3	36.6

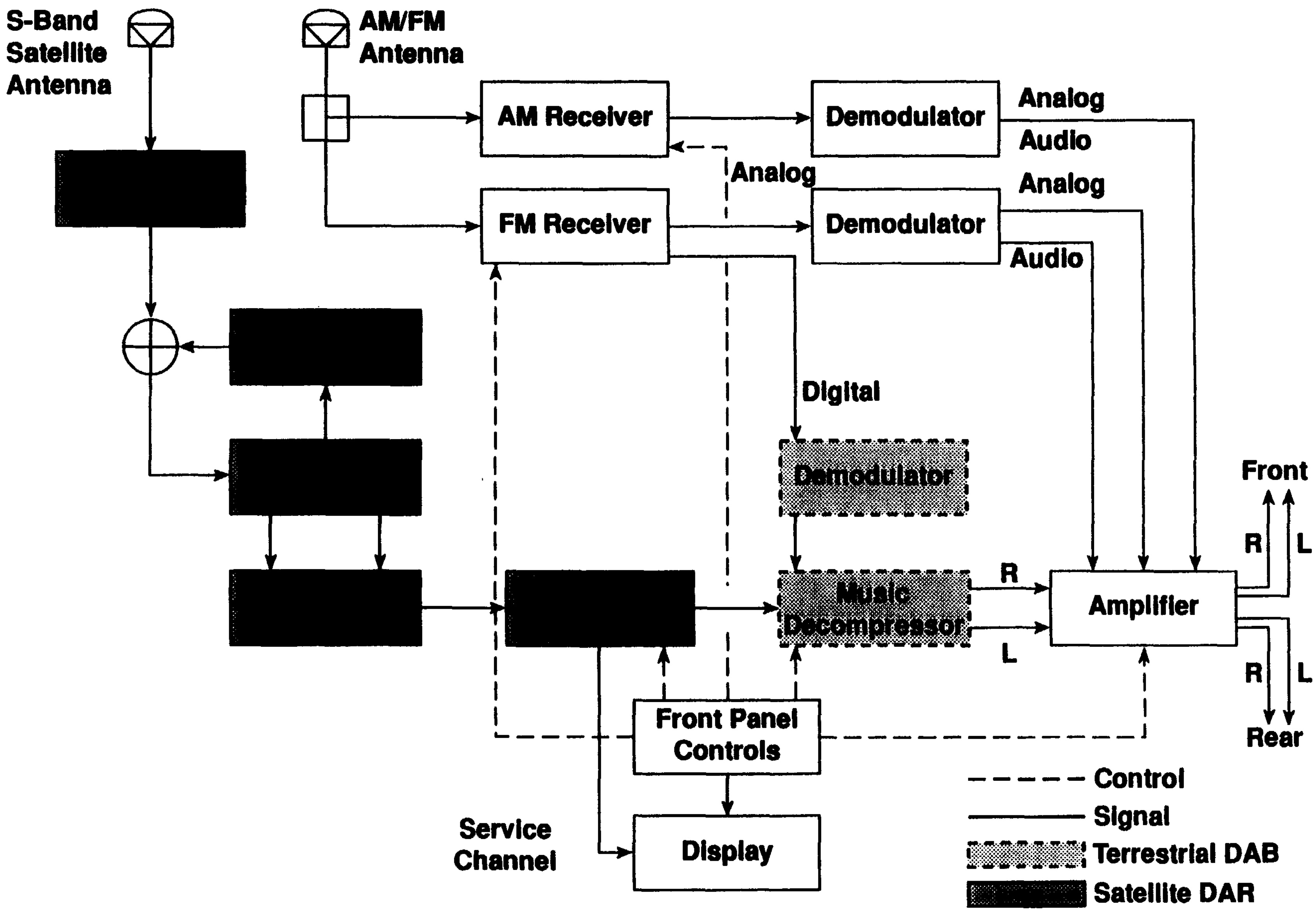
Figure 3 — Dual-Frequency Satellite Radio Broadcast Receiver



* Phase correction may be done alternatively in the Demodulators.

"S" is radio broadcast audio signal (normally connected to audio amplifier and speakers).

Figure 4 — Vehicle Receiver
Analog AM & FM/Digital Satellite & Terrestrial



CD RADIO

Certification of Person Responsible for Technical Information

I hereby certify that I am the technically qualified person responsible for the preparation of the engineering information contained in this Supplement to Pioneer's Preference, including the review of CD Radio's DARS Technology Innovations and the report on CD Radio's second experiment; that I am familiar with Part 25 of the Commission's rules; that I have prepared or reviewed the attached filing; and that it is complete and accurate to the best of my knowledge.

My professional and educational qualifications are fully set out in the attached resume.

By: Robert D. Briskman

Robert D. Briskman
Professional Engineer
DC License # 749008279

Dated: June 2, 1993

Sworn and subscribed to before me
this 2nd day of June, 1993

Roberta P. Barbee

Notary Public

My Commission expires: 1-31-98

CD RADIO

ROBERT D. BRISKMAN

Biography

Robert D. Briskman is Chief Technical Officer of CD Radio Inc. and President of its Systems Group. He has been involved with communication satellite systems since their inception. Mr Briskman is responsible for the development, implementation and management of CD Radio's broadcast distribution system. His technology development responsibility includes design of low cost satellite receiving terminals for automobiles and of direct broadcast sound programming and operational facilities.

Prior to CD Radio, Mr. Briskman was with the Geostar Corporation from 1986-1991. He was responsible at Geostar for the development, design, implementation and operation of the Radio Determination Satellite Service provided by Geostar which allows positioning and message communications between mobile users nationwide and their dispatch centers. Mr. Briskman directed the construction of Geostar's space segment, the control and operations center and the development of the mobile terminals used on land, sea and airborne vehicles built by the SONY, HUGHES Network Systems and KENWOOD Corporations. He was responsible for the development of a miniaturized handheld transceiver by Motorola which was the world's smallest satellite earth terminal. Mr. Briskman served as Senior Vice President, Engineering and Operations.

Mr. Briskman was employed by the Communications Satellite Corporation (COMSAT) in January 1964, and was responsible initially for satellite command and control activities, including those involved with the launching of INTELSAT I (Early Bird). He was later a Department Manager in the Transmission Systems Division, where he was involved with the development and implementation of the INTELSAT global communications system. Among his efforts, early work in demand assigned single carrier per channel, radio frequency interference minimization and terrestrial interconnection was accomplished. Mr. Briskman was responsible from 1967-1973 for the technical planning involved with the provision of domestic communications services via satellites, including AT&T's satellite systems.

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CD RADIO

Mr. Briskman joined COMSAT General Corporation on its founding in 1973 and was Assistant Vice President, Space and Information Systems. He was responsible for the COMSTAR satellite system, the development of earth resource and information systems, and the implementation of the first remote satellite data collection system in conjunction with the United States Geological Survey and Telesat Canada. He directed the construction of the Southbury and Santa Paula earth stations which were used for command and control of both MARISAT and COMSTAR satellites and for shore communications to the Atlantic and Pacific MARISAT satellites. Mr. Briskman joined Satellite Business Systems in mid-1977 where he was responsible for the Pre-Operational Program which provided voice and data communications services to many IBM facilities in the United States using the first demand-assigned, time division multiple access system ever placed in commercial operations.

Mr. Briskman returned to COMSAT General in 1980 where he was responsible as Vice President, Systems Implementation for the engineering of satellites, earth stations and communications technical facilities of COMSAT General and of clients, both within and external to COMSAT. His organization provided a complete range of technical services nationally and internationally, including those involved with software, spectrum engineering and teleconferencing. Mr. Briskman was responsible for the PALAPA (Indonesia's domestic satellite system), ARABSAT and ITALSAT programs as well as for providing support to the INMARSAT, INTELSAT, STC (Direct broadcast), TELSTAR-3, ALASCOM, SATCOL, UNISAT, INTELMET, NORDSAT, CHINASAT AND CAMEROON programs.

Prior to COMSAT, Mr. Briskman joined the National Aeronautics and Space Administration (NASA) during its founding in 1959. At NASA, Mr. Briskman was Chief of Program Support for the Office of Tracking and Data Acquisition. He was involved with the development of ground instrumentation for such projects as APOLLO, GEMINI, RANGER, MARINER, and ECHO. Mr. Briskman received the APOLLO Achievement Award from NASA for the design and implementation of the Unified S-Band System. Before NASA, he was employed by IBM in 1954 and worked on the design of asynchronous buffer systems. After two years of military service as an Electronic Countermeasures Analyst Officer, for which he was awarded the Army Commendation Medal, Mr. Briskman was employed by the Army Security Agency. He was engaged in communications systems development and analysis.

Mr. Briskman is a Fellow and past Secretary-Treasurer, Vice President for Technical Activities and Director of the Institute of Electrical and Electronics Engineers (IEEE). He has been President of the Aerospace and Electronics Systems Society, Director of the National Telecommunications Conference, Chairman of the EASCON Board of Directors, and Chairman of the IEEE Standards Board. Mr. Briskman has authored over forty technical papers, holds

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three United States patents, served on the Industry Advisory Council to NASA, and is a licensed professional engineer. He is a Fellow of the AIAA and the Washington Academy of Science, past President of the Washington Society of Engineers, and a member of IAA, AFCEA and the Old Crows. He is also a recipient of the IEEE Centennial Medal. Mr. Briskman holds a B.S.E. degree from Princeton University and a M.S.E.E. degree from the University of Maryland.

2/3/93

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APPENDIX C

Supplement To Pioneer's Preference Request

Satellite CD Radio, Inc.
Request for a Pioneer's Preference for
Proposed Satellite Digital Audio Radio System
General Docket No. 90-357
PP-24
Filed September 20, 1995

DUPLICATE

Before the
FEDERAL COMMUNICATION COMMISSION
Washington, D.C. 20554

In the Matter of: SATELLITE CD RADIO, INC. Request for a Pioneer's Preference for Proposed Satellite Digital Audio Radio System	 Docket No. PP-24

Supplement to Pioneer's Preference Request

Satellite CD Radio, Inc. (CD Radio), by its attorneys, hereby supplements its pending request for a pioneer's preference in the satellite digital audio radio service (DARS). This supplement is prompted by FCC amendments to its pioneer preference policies, contained in its *Second Report and Order*[1] and *Third Report and Order*.[2] Even under the new rules, CD Radio deserves a preference, and the Commission should speedily designate CD Radio as the satellite DARS pioneer.

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1 Review of the Pioneer's Preference Rules, FCC 95-80 (Mar. 1, 1995).

2 Review of the Pioneer's Preference Rules, FCC 85-218 (June 8, 1995).

I. INTRODUCTION

Over five years ago, on May 18, 1990, CD Radio filed a request to be designated as a pioneer in its newly proposed satellite DARS service. This application was supplemented as new information became available, most recently on June 2, 1993. To refine its technological concepts, CD Radio also obtained a license to begin an experimental test of satellite DARS concept; reports following the progress of this testing have been submitted as available.

This year, the Commission allocated S-Band spectrum,[3] and has proposed rules to govern the licensing and operation of the new service.[4] These decisions came in part through CD Radio's regulatory perseverance that found, cleared, and obtained international approval for, the spectrum and that first proposed specific satellite DARS rules. As previously noted in connection with the above-captioned application,[5] CD Radio warrants a pioneer's preference based, in part, on these regulatory efforts that assisted the Commission in reaching these milestones. Indeed, in its most recent determination on pioneer's preference, the FCC agreed that the rules "already incorporate non-technical or regulatory aspects."[6]

Also this year, the Commission made minor modifications to the pioneer preference policies, most of which concern the planned administrative processing of preference

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[3] Digital Audio Radio Service, 10 F.C.C. Rcd 2310 (1995).

[4] Digital Audio Radio Service, FCC 95-229 (May 15, 1995).

[5] *See* Supplement to Pioneer's Preference Request, PP-24, at 7-11 (filed June 2, 1993).

[6] *Third Report and Order,* ¶ 13.

applications. The *Third Report and Order* required those seeking pioneer's preferences to supplement pending applications to bring them into conformance with the new rules.[7] Although the rules have changed relatively little -- and they support grant of the instant preference -- this document updates CD Radio's request.

II. UNDER THE NEW RULES, CD RADIO STILL IS ENTITLED TO A PREFERENCE

Many of the Commission's rule changes do not require any amendment or clarification to CD Radio's request for pioneer's preference. For example, through its lengthy program of experimentation, CD Radio has already "document[ed] the technical feasibility of [its] innovation with respect to a new technology or service."[8] Similarly, although the new policies limit preference grants to services that require a new allocation of spectrum,[9] the Commission has already granted CD Radio's Petition for Rulemaking seeking such relief.[10] In addition, CD Radio has no objection to the new option of using "peer review" to examine preference applications[11] - so long as this process does not further delay a pioneer preference request now half a decade old. Finally, although the Commission has determined that -- in general --

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7 *Third Report and Order*, ¶ 22.

8 *Second Report and Order*, ¶ 27.

9 *Third Report and Order*, ¶ 21.

10 Digital Audio Radio Service, 10 F.C.C. Rcd 2310 (1995) (granting RM-7400).

11 *Third Report and Order*, ¶ 18.

pioneers must pay for their licenses in a lottery,[12] CD Radio has demonstrated that competitive bidding may not legally or equitably be imposed in this case.[13]

The two new rules warranting supplement are, first, that the applicant provide a "summary of experimental results" that establish that a preference is warranted,[14] and second, a demonstration that, if its application is subject to competitive bidding, it "may lose its intellectual property protection because of [the Commission's] public process" and that "guarantee of a license is a significant factor in [the applicant's] ability to capture the rewards from its innovation."[15] Regarding the first requirement, appended hereto is a Summary of Experimental Results, authored by Robert Briskman of CD Radio, showing that CD Radio's testing and experimentation to date justify the award of a preference.

With respect to the second requirement, the Commission is required to examine the overlap between preferences and intellectual property. Put differently, if a pioneer can obtain sufficient rewards from the licensing of its innovation, the Commission sees no need to award

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12 *Id.*, ¶ 19-23.

13 *See* Comments of CD Radio, IB Docket 95-91, at 34-45 (filed Sept. 15, 1995). Even if competitive bidding is adopted, in recognition of the huge investment CD Radio has made in satellite DARS and funding regulatory efforts, the Commission has proposed granting bidding credits over and above the pioneer's 15 percent. *Notice of Proposed Rulemaking*, ¶ 35.

14 *Second Report and Order*, ¶ 27.

15 *Third Report and Order*, ¶ 19. The Commission requires such a demonstration "even if the Commission has not yet determined that the particular service for which a preference is sought will be subject to competitive bidding," *id.*, which covers satellite DARS.

a preference. Plainly, however, existing intellectual property laws are ill-suited to reward CD Radio, for several reasons.

First, the long delay in licensing satellite DARS is itself reason to declare CD Radio a pioneer. The agency's preference policies are supposed to reward *and encourage* innovation. But CD Radio's preference request is now over *five years old*. Because of the time required to construct and launch satellites, service for the public cannot begin for several more years. Any returns from intellectual property licensing, therefore, have been so long delayed to diminish their value, especially when considered at the time of the initial filing. Absent a preference, therefore, CD Radio will not enjoy full recovery for the fruits of its labors.

Second, the long delay imperils incentives for future innovations -- the *raison d'etre* of the preference scheme. The motivation of entrepreneurs to propose new services to the public using new spectrum can be diminished, if not destroyed, merely by the length of time the agency takes to make up its mind. If a pioneer such as CD Radio were obliged to seek recovery for its technical innovation without the benefits of a preference, the next generation of ideas may never make it beyond the drawing board.

Third, during this long delay, CD Radio's application and experimental system have been on public file, available for all to copy. Other entities may have borrowed elements of CD Radio's concepts and incorporated them into competing applications and current plans. If licenses are thereafter awarded by auction, CD Radio manifestly will have forfeited its head start.

Finally, it is doubtful that the company will be able to enjoy a full recovery for its efforts merely through intellectual property licensing. The pool of potential satellite DARS applicants is small -- just three other entities, each with relatively small markets at the outset.[16] Even if all were licensed and built systems, it is far from clear at this stage how many of them -- if any -- desire to use CD Radio's technology. Absent a preference, there is a substantial chance CD Radio will not receive full value for its innovations.

III. CONCLUSION

CD Radio's preference application shows it to be an innovator worthy of designation as pioneer. The policies recently adopted in the *Second* and *Third Reports and Order* are entirely consistent with this view; indeed, as the attachment demonstrates, CD Radio's existing experimentation provides ample evidence of its pioneering activities. Moreover, CD Radio's probable inability fully to recover the value of its innovations through intellectual property licensing provides additional support for the prior requests in this docket.

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[16] By way of contrast, the Commission plans to issue more than 2,000 broadband PCS licenses. An innovation useful in broadband PCS -- a CDMA transmission scheme, for example -- could undoubtably count on numerous intellectual property licenses covering tens of millions of subscribers.

For the reasons expressed in five years' of filings -- which demonstrate that CD Radio conceived of, designed and started satellite-based audio services and developed several innovative technologies to supply the service -- the Commission should grant CD Radio a pioneer's preference in the licensing of satellite DARS as soon as possible.

Satellite CD Radio, Inc.

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Dated: September 20, 1995

Summary of Experimental Results

INTRODUCTION

Over half a decade ago, CD Radio proposed to the Commission that a new United States domestic satellite service, hereafter termed Satellite Digital Audio Radio Service (SDARS), be established which would provide multiple music and other audio programs directly to users in their homes and automobiles. CD Radio then undertook a multiyear effort to work with the government to locate suitable spectrum for SDARS and to develop technology which would enable SDARS to be provided effectively and economically. The spectrum (2310-2360 MHz) was located and internationally allocated in February 1992 (see Attachment 1) and a parallel experimental effort on technology development was successfully demonstrated in stages, the first being in December 1991, with subsequent result demonstrations continuing through to the present. All experiments using external radio frequency transmissions were conducted under FCC Experimental License K02XES File 3481-EX-PL-92 originally authorized February 25, 1993.

OVERVIEW

CD Radio undertook the development and demonstration of new technology in order to prove that SDARS could be offered effectively and economically. One technical problem was to maintain high service quality in a mobile user environment by mitigating reception outages caused by blockage (i.e., large obstructions between the satellite and vehicle such as buildings, hills, overpasses, etc.), multipath (i.e., Ricean, Rayleigh, reflective and frequency selective) and fading from partial obstructions such as tree limbs or foliage. The innovative solution to this problem pioneered by CD Radio was through the use of satellite spatial and frequency diversity. The next technical problem was to minimize required satellite power per channel in a bandwidth restricted environment so a reasonable number of channels (e.g., 35) could be provided economically. The solution to this problem was through use of improved music compression and transmission encoding/multiplexing techniques.[1] The last technical problem was to develop a mobile user radio which is easily operated by the general public, economic and aesthetically acceptable. The solution of CD Radio was through the development of a microminiature antenna and a single additional radio button.

EXPERIMENTS

1. Fixed Location. Indoor through window reception SDARS system at C-band radio frequency using notebook size antenna. Demonstrated two CD stereo music channel capability using 256 kb/s compression and fully automated user subscription system. June 1991 - February 1992.

2. Compression. Using special audio listening facilities and over 100 listeners, evaluated 3 compression techniques. June 1992 - November 1993.

3. Satellite Spatial/Frequency Diversity. Outdoor range of several miles using satellite emulators at S-band and demonstrational automobile with CD Radio developed antenna and radio. Demonstrated mobile reception of 30 CD stereo music channels using 128 kb/s compression. March 1992 - present.

[1] Comments of CD Radio, FCC Filing of Sep. 15, 1995; IB Docket 95-91; GEN Docket No. 90-357; RM No. 8610; Appendix B.

4. Overpass Blockage. Outdoor range specially instrumented to measure overpass blockage outage mitigation by emulated satellite spatial diversity transmitters at S-band. April 1993 - June 1993.

5. Tracking and Data Relay System (TDRS). Pursuant to a Space Act Agreement[1] between the National Aeronautics and Space Administration (NASA) and CD Radio, the demonstrational vehicle was used for wide area spatial diversity and cross polarization measurements of specially configured TDRS satellite transmissions at S-band. March 1994 - present.

RESULTS

1. Fixed Location. This was the first-ever delivery in the United States of multiple channel CD quality stereo music directly from an actual satellite into a notebook size consumer type indoor antenna. The experiment further demonstrated the first-ever fully automated user subscription satellite radio service, the ability to intersperse text messages (i.e., music titles, performers, etc.) within the transmission and the quality of music after compression/decompression. Public demonstrations were held for the FCC and for experts and the engineering data fully reported.[2]

2. Compression. The results showed that Perceptual Audio Coding (PAC) at a 128 kb/s transmission rate was the preferred compression technique. This allowed the doubling of the number of music channels provided in CD Radio's system configuration without increase in satellite radiated power or bandwidth, since prior to this CD music compression required a 256 kb/s transmission rate.

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[1] Non-Reimbursable Space Act Agreement Between NASA Lewis Research Center and CD Radio Inc. for Testing of Satellite Digital Audio Radio dated 5/25/94.

[2] Pioneer's Preference Supplement, Satellite CD Radio, Inc.; FCC Filing dated January 23, 1992.

3. Satellite Spatial/Frequency Diversity. CD Radio's test system replicated all significant technical aspects of its SDARS architecture. Using this system, CD Radio was able to receive in a mobile vehicle emulated satellite signals with insignificant outages while driving through an environment having significant blockage and multipath and logged empirical results consistent with its theoretical analyses. These data are detailed in the experimental report[1] and show:

- The feasibility of satellite delivered DARS to mobile receivers using S-Band frequencies in typical multipath environments;
- Mobile reception of SDARS signals duplicating received power levels and elevation angles representative of CD Radio's technical system design, including seamless reception during transit of blockage environments;
- Extremely small, low-gain roof-recessed omnidirectional antennas;
- Simultaneous mobile reception of 30 channels of digital audio data, at data rates of 128 kb/s using PAC, plus a multiplexed 128 kb/s service channel.

The field experiments used a prototype SDARS receiver that CD Radio designed, constructed, and integrated into a conventional car radio system. Using this receiver and CD Radio's silver dollar-sized planar array microantenna, both reception of SDARS signals as well as network control over remote mobile receivers were demonstrated. The test system also implemented all of the control and display functions of the CD Radio SDARS system, enabling proof of user acceptance of the human interface and ease of car radio operation.

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[1] Supplement to Pioneer's Preference Request, Satellite CD Radio, Inc.; FCC Filing dated June 2, 1993; Appendix A.

4. Overpass Blockage. Attachment 2 (Figure A1-2) summarizes the results. This figure shows the average of the F1 satellite emulator received signal measurements with a dotted line and the F2 satellite emulator received signal measurements with a solid line along the vehicle drive path. Also shown are the physical location of the overpass and the physical location of blockage outage from a geometrical calculation. The results demonstrate:

> A vehicle equipped to receive both satellite emulation transmitters would have no blockage outage if the receiver either combined the two signals or switched in the vicinity of the 370 foot location as would occur in CD Radio's receiver design.
>
> Geometrical calculations of overpass blockage are accurate representations of SDARS radio frequency transmission outage.
>
> No anomalous propagation effects were found due to reflection, diffraction or ducting at the S-band frequencies used (2310-2360 MHz band).

5. TDRS. Two series of measurements have been made so far. The results show that wide area (i.e., several hundred miles) satellite received transmissions are very similar with regard to service quality as those measured on the narrow area test range described in the preceding Paragraph 3. The results also demonstrate that polarization isolation is a useful SDARS technical design characteristic. Details of the initial test and data have been submitted to the FCC.[1]

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[1] CD Radio experimental report; FCC letter from Wiley, Rein & Fielding to William Caton dated July 24, 1995.